Theory of unconventional Smith-Purcell radiation involving photonic crystal

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A running charged particle induces a coherent radiation when it passes above a periodic dielectric structure such as photonic crystal (PhC). Conventionally, this radiation, so-called Smith-Purcell radiation (SPR), can be understood as a consequence of the Umklapp scattering of the evanescent wave accompanied by the charged particle. However, when an ultra-relativistic electron beam is used in the experiments of the SPR in PhC, unexpected phenomena contrary to the conventional understanding of the SPR are observed [1]. This unconventional SPR has several remarkable properties such as a peculiar angular distribution of the induced radiation.

Here, we present a theoretical analysis of the unconventional SPR in a PhC composed of cylinders by using the multiple-scattering formalism [2]. The analysis shows that the above properties are reasonably understood by taking account of the boundary of the PhC. It also predicts various finite size effects, an additional selection rule, and the interplay between the conventional and unconventional SPRs.

[1] N. Horiuchi et al., in preparation.
[2] T. Ochiai and K. Ohtaka, *Phys. Rev.* B 69, 125106, 125107 (2004).